A New Chemical Mechanical Polishing Method using the Frozen Etchant Pad

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In sub-micron ULSI semiconductor process, there were several innovative process, which make possible to reduce the cell size continuously, such as high resolution lithography, Shallow Trench Isolation process (STI), Chemical Mechanical Polishing (CMP) and so on. Especially, the CMP process was one of the most innovative processes being used in the STI process, metal interconnection (W-plug and copper metallization with dual damascene process), and Inter Metal Dielectric process (IMD) [1,2]. Conventional CMP process uses various slurries and polish pads. However, Several difficulties are appearing in the CMP process, such as unstable slurries, scratches on the surface, various metal contaminants, the dishing problem, cleaning difficulties, selectivity, high process cost and so on [3,4].

In our study, we are going to propose the new method of CMP process. Figure 1 shows our process scheme. We have used the frozen etchant pad instead of conventional polishing pads and slurries. Our frozen etchant pad is made by freezing the etching solution. In our CMP process, the wafer is attached and rotated on the pad and we control the temperature and the wafer pressure against the polishing pad. Therefore, the frozen etchant of the pad melt only in the places that wafer is attached and those attached places is etched and finally polished.

We have performed experiments for polishing the IML and metal interconnection lines in the damascene structures. We have used the patterned wafer, which is patterned with the various widths of line and space. The etchant solution was frozen in the cooling pad using liquid nitrogen circulate system. We have polished the wafer on the etchant frozen pad with various conditions, which contains the composition of etchant, the wafer temperature, polishing speed, the wafer pressure against frozen pad, and so on. After polishing process, we studied the polished wafer by AFM analysis and we could find the reduction in the step height between lines and spaces. As shown in Fig. 1, the height of line and space is drastically reduced from 3400 Å to 1400 Å. Also, we have analyzed the surface roughness after polishing process and we found that the vert distance of lines decreased from 200 Å to 100 Å in Fig. 3. This means we are able to platen the surface and decrease surface roughness simultaneously because we do not use the slurries.

From our experiment results, we have found the possibility in our new CMP process using frozen etchant pad. Furthermore, we can expect to completely solve the issued problems of present CMP process, which are the high process cost due to slurry and polishing pad, the contaminant, scratches, dishing problem and the increase of surface roughness after cleaning process.

References

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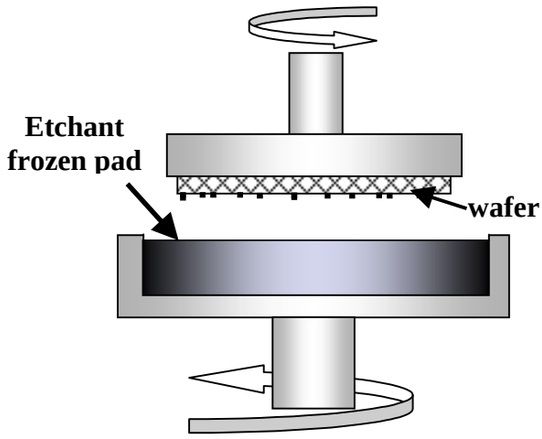
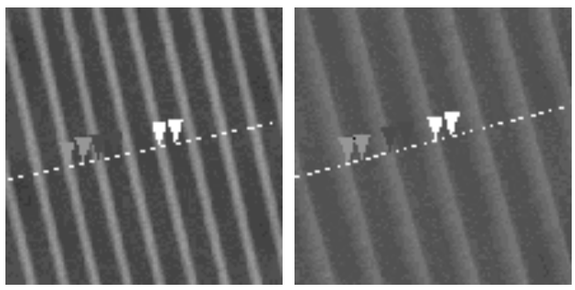
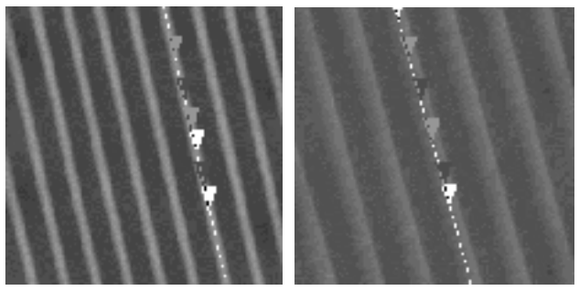


Figure 1. The scheme of the polishing apparatus using a frozen etchant pad.



(a) **(b)**

Figure 2. The AFM images of step height reduction; (a) Before the polishing process, the height of line and space is about 3400 Å, (b) After the polishing process, the height of line and space is about 1400 Å



(a) **(b)**

Figure 3. The AFM images of surface roughness reduction; (a) Before the polishing process, the vert distance of the line is about 200 Å, (b) After the polishing process, the vert distance of the line is about 100 Å